



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>6</sup> : <b>H04Q 7/20</b>	<b>A1</b>	(11) International Publication Number: <b>WO 99/23842</b>
		(43) International Publication Date: 14 May 1999 (14.05.99)

(21) International Application Number: PCT/US98/16151

(22) International Filing Date: 31 July 1998 (31.07.98)

(30) Priority Data:  
08/961,854 31 October 1997 (31.10.97) US

(71) Applicant: MOTOROLA INC. [US/US]; 1303 East Algonquin Road, Schaumburg, IL 60196 (US).

(72) Inventors: SCHOLEFIELD, Christopher; 11928 Sunwood Place, Delta, British Columbia V4E 2X6 (CA).  
ONO-TESFAYE, Theodore; 9201 112th Street #3B, Edmonton, Alberta T6G 2C5 (CA).

(74) Agents: WHITAKER, Charlotte, B. et al.; Motorola Inc., Intellectual Property Dept., 1303 East Algonquin Road, Schaumburg, IL 60196 (US).

(81) Designated States: AU, CA, CN, DE, FI, GB, IL, SE.

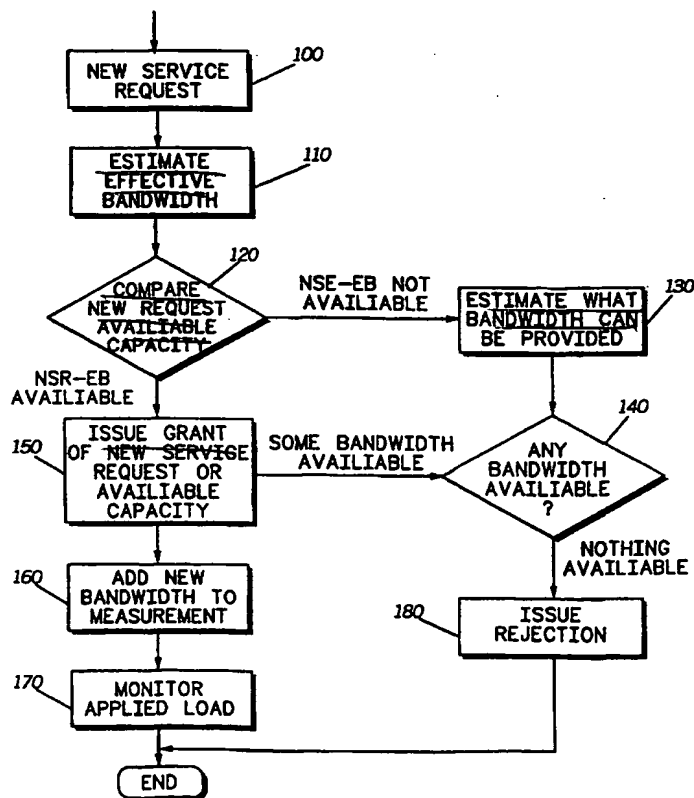
Published

With international search report.

(54) Title: METHOD FOR AN ADMISSION CONTROL FUNCTION FOR A WIRELESS DATA NETWORK

## (57) Abstract

A method for allowing new traffic on a wireless data network. A service request is received from a mobile station (100). An effective bandwidth of the service request is estimated (110) using a recursive estimator (400). If there is enough surplus capacity on the wireless data network to accommodate the service request, the service request is granted. In response, a discrete adjustment, based on the effective bandwidth, is applied (160) to the recursive estimator (400).



**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

METHOD FOR AN ADMISSION CONTROL FUNCTION  
FOR A WIRELESS DATA NETWORK

Field of the invention

5

The present invention relates generally to admission control function for a wireless data network.

Background of the Invention

10

Wireless data networks aim to provide users with guaranteed quality of service (QoS) levels while allowing network operators to exploit the statistical multiplexing gain associated with the fact that there are many users sharing multiple resources (i.e., the users not having those multiple resources solely dedicated to their individual requirements). This is in part due to the fact that the resource requirements of N multiplexed users, which may be bursty in nature, are less than the sum of the individual resource requirements for each user.

QoS guarantees require some kind of resource allocation. Following the conventional vocabulary, the period during which the resources, which are typically real circuits and switches, are allocated is referred to as a physical connection for a duration of a real circuit. When using statistical multiplexing, in contrast to the conventional vocabulary, the period during which the pool of shared resources are reserved is referred to as a "context" (i.e., logical connection) for a duration of a virtual circuit. In a wireless data network, this "context" begins with the activation of a packet data protocol virtual circuit (i.e., carrying packets from different external networks) and ends with the deactivation of the packet data protocol virtual circuit. This should not be confused with the fact that

35

in a wireless data network there are both connection-oriented and connection-less services offered to applications. For instance, even if an application uses the internet protocol-type connection-less services of a wireless data network, there is a logical connection between the network layers in the mobile station and the base station. It is at this level that the admission control function operates. The admission control function of a wireless data network decides for each incoming virtual circuit request whether a sufficient aggregate pool of shared resources are available to satisfy the virtual circuit QoS requirements. The resources are dedicated to a particular virtual circuit only as they are actually needed to effect a data transfer and only for the duration of the transfer.

To perform resource allocation, the admission control function must be able to determine the load on each element of the network as well as its own network sub-systems. This includes but is not limited to any external network such as a packet data network, public switched telephone network, wireless data network, or neighboring public land mobile network, as well as its own network sub-system and base station sub-system. The admission control function is the central measurement consolidation and decision point for admitting new service requests to the network. This function could be placed at any node in the network such as the general packet radio service (GPRS) support node, the base station, the network management center or the mobile switching center to name a few.

In general, the load on a particular element of the network can be determined in two ways: (1) by looking at the accumulation of the previously granted service requests; and (2) by measuring the real load on the network. Measurement of the network load is usually performed by a network node such as a general support

node or base station. Unfortunately, there are problems with determining the load on the networks, such as, responsiveness to load fluctuations and accuracy of accumulating service requests.

5        Measurement-based approaches particularly suffer from the following problem. With these methods there is a time delay during which the measurement must adjust to new traffic (i.e., service requests) that has been recently admitted to the network. During this period,  
10       the network can receive a new service request and grant this request believing that the wireless data network has enough surplus capacity to support the request. In fact, however, the wireless data network may not have enough surplus capacity because of the time delay  
15       associated with the measurement adapting to the previously admitted service request.

Admission control functions for the provision of the QoS have been investigated in Asynchronous Transfer Mode (ATM) networks. These ATM networks operate at very  
20       high speed (typically above 150 Mbps) and over reliable wired or optical fiber links. With such a high transmission speed, the admission control function can be non-optimal by being conservative in resource allocation and reserving more bandwidth than is  
25       minimally necessary to achieve the QoS. ATM networks normally carry a mixture of QoS classes including constant bit rate and variable bit rate with fixed delay. These classes are intended for use to transmit voice or video in which the delay is more important than  
30       the reliability of delivery (i.e., if the data is delayed then the data may be discarded rather than reliably delivering it). In contrast, wireless data networks have relatively low transmission speeds, typically below 200 Kbps, which must be highly  
35       optimized. In addition, data reliability is normally more important in wireless data networks than the delay.

Robust transmission link methods such as forward error correction and automatic repeat request are necessary to achieve data integrity over the wireless data link which may be subjected to high levels of interference.

5        In conclusion, the existing admission control functions do not sufficiently satisfy the needs for efficient resource reservation in wireless data networks. Thus, there exists a need to improve the admission control function algorithms for networks in  
10        general, and in hybrid networks in particular, which may include wireless components which might exhibit limited bandwidth capacity or unreliability due to high levels of interference.

15

#### Brief Description of the Drawings

A preferred embodiment of the invention is now described, by way of example only, with reference to the  
20        accompanying drawings in which:

FIG. 1 is a flow chart for allowing new traffic on a wireless data network according to the present invention;

25        FIG. 2 is a graph representing bandwidth utilization under different delay constraints according to the present invention;

FIG. 3 is a diagram representing theoretical channel capacity according to the present invention; and

30        FIG. 4 is a block diagram of a recursive estimator according to the present invention.

### Detailed Description of the Preferred Embodiment

In networks in general, and in wireless data networks in particular, resources must be reserved in order to provide users with guaranteed quality of service (QoS) levels. As stated previously, the admission control function of a wireless data network decides for an incoming service request whether enough resources are available to satisfy the QoS requirement of an incoming service request. The present invention provides a method of determining whether additional service requests (i.e., traffic) can be admitted on the wireless data network while maintaining quality of service levels across the network and, as a consequence, to each user on the network.

Referring to the drawings, FIG. 1 is a flow chart for allowing new traffic (i.e., service requests) on a wireless data network according to the present invention. Before sending any data, the admission control function is initiated by a service request from a mobile station which is sent to a base station at step 100. In this service request, the mobile station must specify the QoS with traffic descriptors such as the mean bit rate, the peak bit rate and the requested delay. There are other parameters such as burst size, burst duration, and duty cycles which also may be used depending on the particular method chosen to describe the service requests.

The effective bandwidth of the new service request is estimated using the QoS parameters at step 110. FIG. 2 is a graph representing bandwidth utilization under different delay constraints according to the present invention. As shown in FIG. 2, the effective bandwidth is the amount of bandwidth that has to be reserved in order to meet the QoS requirements. This value is

between the mean bit rate and the peak bit rate. The actual value depends on what delay the user desires from the wireless data network. The delay requirements of each service request corresponds to a class of service which indicates the amount of delay that can be tolerated by the user. For example, as shown below in Table 1, a GPRS class 1 service request can tolerate a mean packet data unit delay of 0.5s. A request for low delay requires a greater weight applied to the peak estimate. It is found that a simple estimate of effective bandwidth is a weighted sum of the mean and peak bit rates, where the weights are fixed and predetermined for the delay class of service. The weight values may be implemented in the form of a simple lookup table for the delay class.

Class	Mean (128 octets)	95%- tile	Mean (1024 octets)	95%- tile
1	0.5s	1.5s	2s	7s
2	5s	25s	15s	75s
3	50s	250s	75s	375s

Table 1 GPRS QoS classes and mean packet data unit delay requirements.

Returning back to FIG. 1, once the effective bandwidth of the new service request is estimated at step 110, the admission decision is made at step 120. The admission decision is determined by testing whether there is enough surplus capacity on the wireless data



network to accommodate the effective bandwidth of the service request.

FIG. 3 is a diagram representing theoretical channel capacity according to the present invention. As shown in FIG. 3, one of the unique attributes of the present invention is the use of a combination of the measured load on the network 10 and the effective bandwidth of the new service request 12 using a recursive estimator (discussed in detail with respect to FIG. 4) with discrete adjustments by the admitted traffic load (i.e., effective bandwidth of the new service request 12) to provide an optimal estimate of the measured load on the network. The surplus capacity (unused bandwidth) 36 is found from the theoretical channel capacity 34 minus the current wireless data network load estimate 30 of effective bandwidth. Wireless data network load estimates 30 are determined from measured load samples, using a filtering method in the form of the recursive estimator.

FIG. 4 is a block diagram of the recursive estimator according to the present invention. The recursive estimator 400 has the effect of filtering the load samples with a greater weight being applied to more recent samples, and it is possible to add occasional corrections whenever a jump in the load is expected (i.e., when a new call is admitted or a call is terminated). The algorithm is as follows:

- the recursive estimator 400 is used to estimate the current used/ unused bandwidth; add/subtract the mean rate as a correction whenever a call is admitted or terminated;
- the bandwidth requirement of new calls is estimated as a weighted sum of peak and mean rates;

- calls are admitted if the bandwidth requirement of the new call is less than the estimated unused bandwidth.

5       The parameter "a" in the recursive estimator 400 is called the filter gain and in the preferred embodiment it controls the ability of the recursive estimator 400 to respond to traffic load fluctuations. The parameter "a" has to be set according to the prevailing system  
10 conditions. Values closer to 1 make the recursive estimator 400 more sluggish (but less prone to random fluctuations), whereas smaller values make the recursive estimator 400 react more quickly to network changes. The value of the parameter must be constrained to be  
15 between 0 and 1. Because of the possibility of adding corrections to the estimate, the recursive estimator 400 is extremely advantageous during periods when the number of connections change rapidly (e.g., during network startup).

20       Returning to FIG. 1, when sufficient surplus capacity is available, the admission control function issues an admission grant to the mobile station as shown in step 150. In response, a discrete adjustment of the new bandwidth (i.e., the effective bandwidth of the new  
25 service request) is applied to the recursive estimator 400 at step 160. In this way, the load estimate is instantaneously adjusted by the recursive estimator 400 by the level of the effective bandwidth of the new service request. This is done to avoid further service  
30 requests from being granted before the recursive estimator 400 has reached a steady state condition with the newly admitted traffic (i.e., the new service request). In the final step, the load on the wireless data network is monitored at step 170 using the  
35 recursive estimator 400, so that any deviation from the

effective bandwidth of the new service request and the actual admitted traffic is eliminated.

When sufficient surplus capacity is not available at step 120, the admission control function estimates the bandwidth that is available and estimates what can be provided at step 130. Step 140 determines if there is any bandwidth available. If there is bandwidth available, the admission control function issues a grant at step 150 indicating the amount of bandwidth which the service request may use. If there is no bandwidth available at step 140, step 180 is taken and the admission control function rejects the service request and notifies the mobile station of the rejection. On receipt of the rejection, the mobile station may modify the request and submit a new service request if a lower peak, mean data rate or longer delay can be tolerated. If this is the case, the mobile station initiates a new request and the entire procedure is started over again.

In the preferred embodiment, a hybrid admission control function algorithm is used in determining whether to admit new traffic. The hybrid algorithm has three internal control parameters: (1) the filter gain; (2) the averaging interval for the delay monitoring; and (3) a normalized threshold of delay. These parameters are internal to the network only and can be set according to the prevailing traffic conditions. These parameters are for control of the admission control function algorithm only and are not exchanged between the mobile station and the network. The hybrid admission control function algorithm uses a combination of the measured load on the network and delay monitoring. The hybrid technique accepts a service request only if both criteria are acceptable. The measured load on the network is described above with respect to FIGS. 1 through 2. Delay monitoring estimates the normalized packet delay directly, rather than relying on indirect

congestion indicators like the measured load on the wireless data network. The normalized delay is derived from the ratio of measured delay and requested QoS. Thus, delay monitoring can detect situations where QoS requirements are not met even though the load on the wireless data network is relatively low. The delay monitoring algorithm is as follows:

- keep an estimate of the average of the last normalized network layer PDU delays incurred in each QoS class; and
- admit the new service request as long as the estimated delays are less than a threshold in all QoS classes.

15

In the hybrid technique, the quality of service parameters are delay and bit rate. The delay is a mean packet data unit delay that the mobile station experiences when transporting packets through the wireless data network. Each service request corresponds to a class of service which indicates the amount of delay that can be tolerated by the service request. The bit rate is a transmission rate of a packet data unit through the wireless data network. Thus, in the hybrid technique, the admission control function determines whether there is enough surplus capacity on the wireless data network to accommodate the service request and determines whether a mean packet data unit delay in the wireless data network is less than a specified delay indicated from the QoS parameters in the service request. If both of the criteria are satisfied, then the service request is granted.

Various alterations, modifications and variations will be apparent to those skilled in the art in light of the foregoing description. While the invention has

35

been described in conjunction with specific embodiments thereof. The invention, in its broader aspects, is therefore not limited to the specific details, representative apparatus and illustrative examples shown and described. Thus, it should be understood that the invention is not limited by the foregoing description, but embraces all such alterations, modifications and variations in accordance with the spirit and scope of the appended claims.

We claim:

1. A method for admitting new service requests having quality of service requirements on a wireless data network having quality of service parameters comprising:
  - 5 receiving a service request having quality of service requirements from a mobile station;
  - estimating a load on the wireless data network using a recursive estimator to provide a load estimate;
  - 10 determining an effective bandwidth of the service request;
  - determining that the quality of service parameters of the wireless data network satisfy the quality of service requirements of the service request;
  - 15 granting the service request; and
  - applying a discrete adjustment, based on the effective bandwidth of the service request, to the load estimate using the recursive estimator.
- 20 2. The method of claim 1 wherein the quality of service parameters are based on a delay.
3. The method of claim 2 wherein the delay is a mean packet data unit delay that the mobile station  
25 experiences when transporting packets through the wireless data network.
4. The method of claim 1 wherein the quality of service parameters are based on a bit rate.
- 30 5. The method of claim 4 wherein the bit rate is a transmission rate of a packet data unit through the wireless data network.
- 35 6. The method of claim 1 wherein the quality of service parameters are based on a delay and a bit rate.

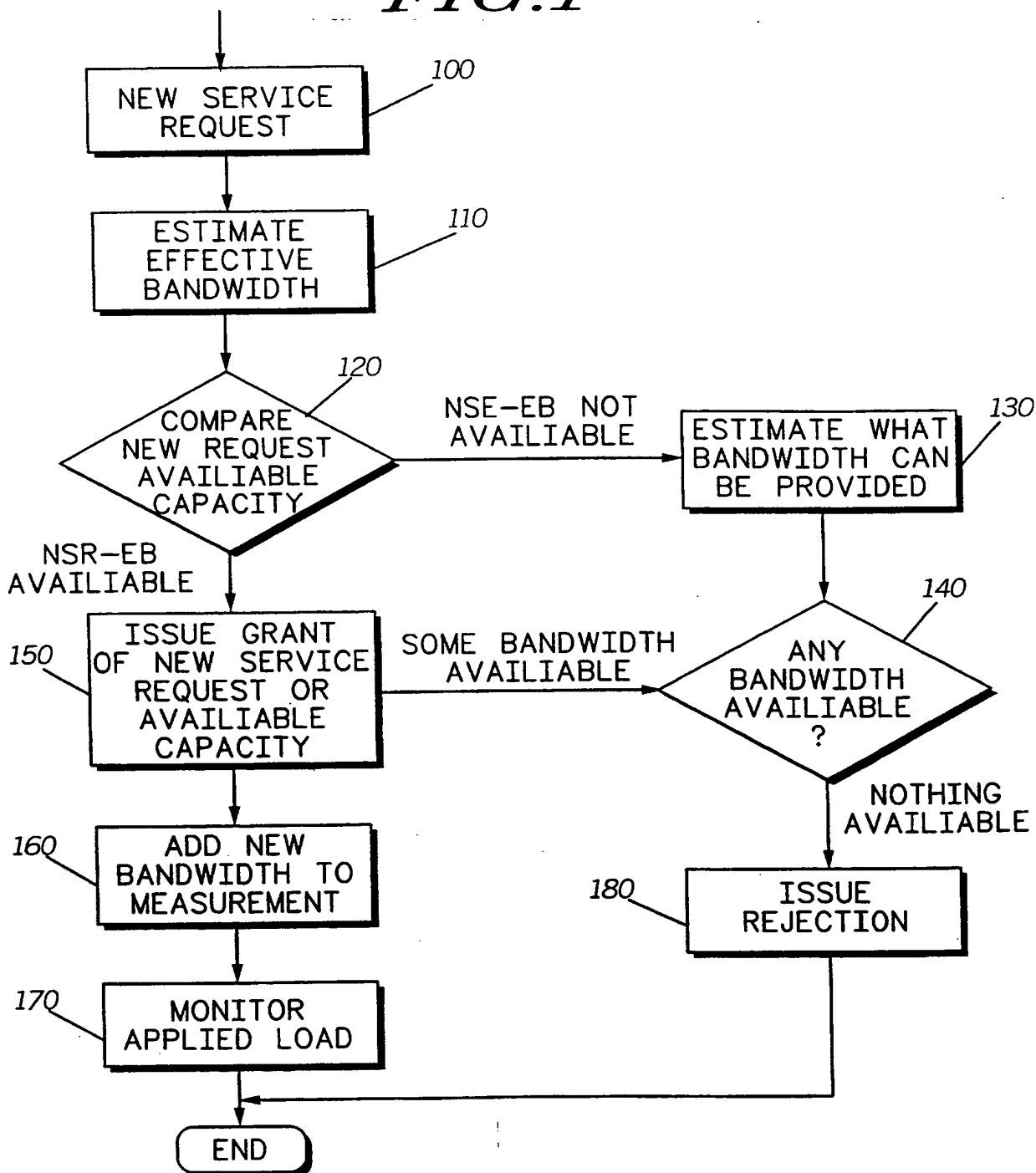
7. The method of claim 6 wherein the delay is a mean  
packet data unit delay that the mobile station  
experiences when transporting packets through the  
5 wireless data network and the bit rate is a transmission  
rate of a packet data unit through the wireless data  
network.

8. The method of claim 1 wherein the quality of  
10 service requirements of each service request correspond  
to a class of service which indicates an amount of delay  
that can be tolerated by the service request.

9. The method of claim 8 wherein the step of  
15 determining comprises determining that there is enough  
surplus capacity on the wireless data network to  
accommodate the service request and determining that a  
mean packet data unit delay in the wireless data network  
is less than a specified delay indicated from the class  
20 of service of the service request.

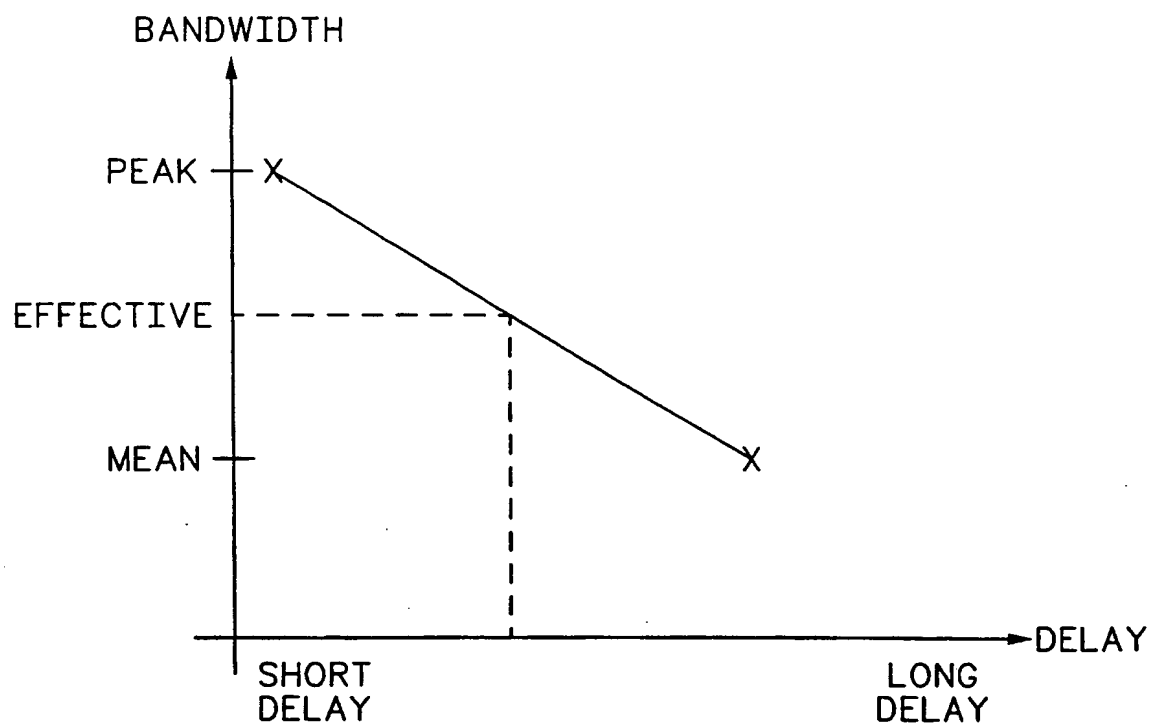
10. An apparatus for allowing new traffic on a wireless  
data network comprising:  
a receiver to receive a service request from a  
25 mobile station having an effective bandwidth;  
a transmitter to transmit an admission grant to the  
mobile station; and  
a recursive estimator to provide a load estimate  
which is an estimate of a load on the wireless data  
30 network and, responsive to the admission grant, to make  
an adjustment to the load estimate based on the  
effective bandwidth of the service request.

1/4

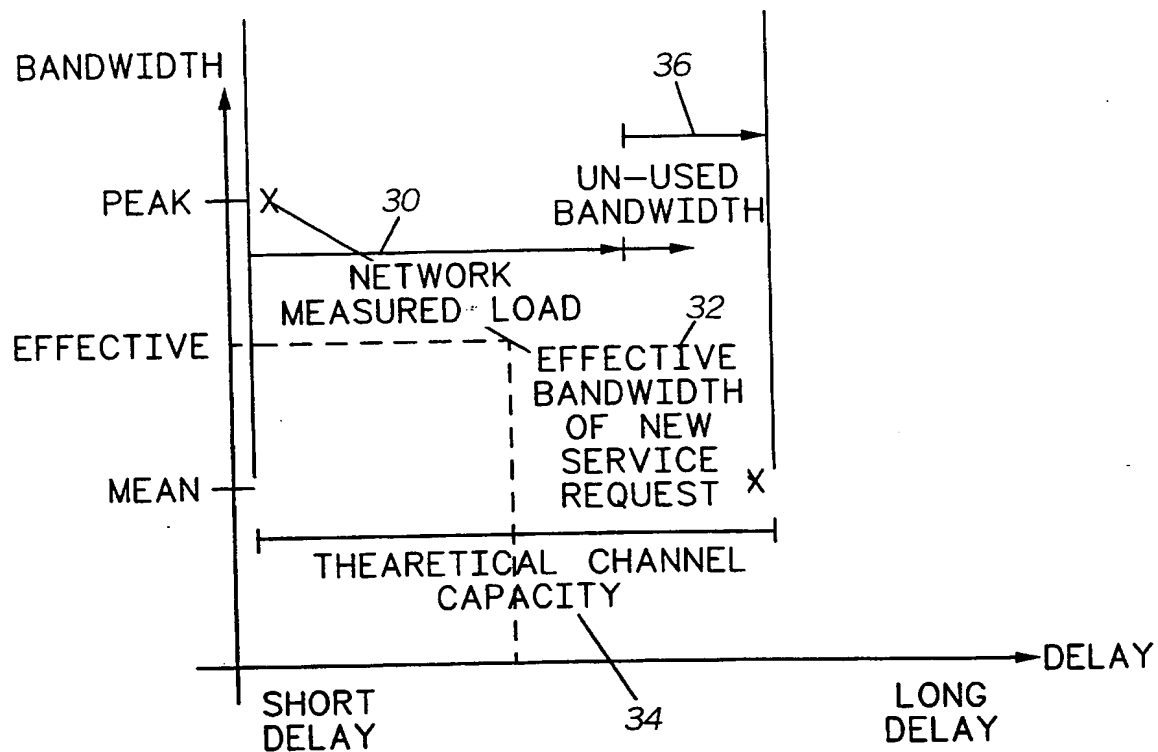
*FIG. 1*



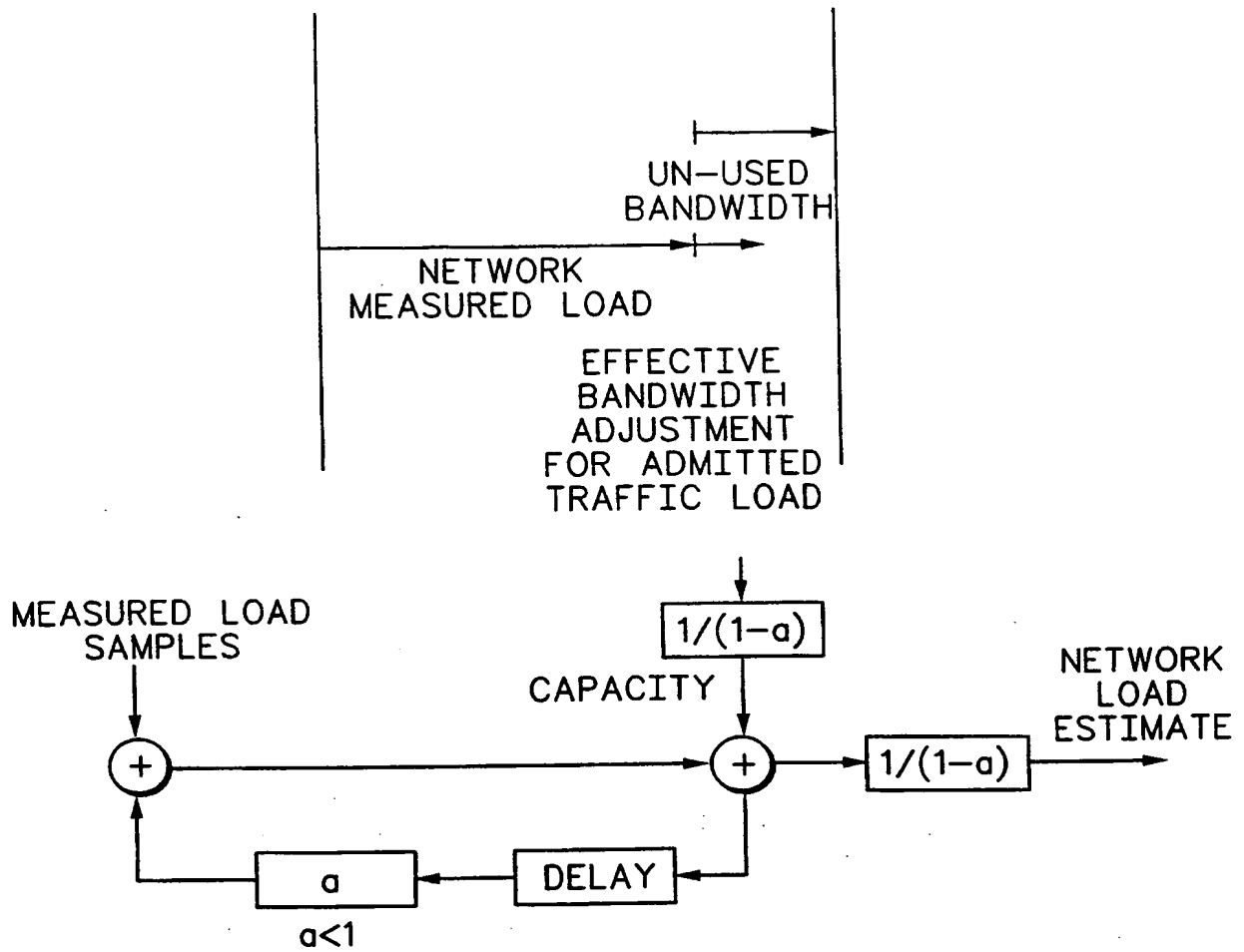
2/4

*FIG. 2*

3/4

*FIG. 3*

4/4

*FIG. 4*

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US98/16151

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : H04Q 7/20  
US CL : 455/62,422,450-453,464,509; 370/230,232,234,329,341,349,468  
According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 455/62,422,450-453,464,509; 370/230,232,234,329,341,349,468

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	US 5729531 A (RAITH ET AL) 17 MARCH 1998, SEE ENTIRE REFERENCE.	1-10
X	US 5,673,259 A (QUICK, JR.) 30 SEPTEMBER 1997; SEE ENTIRE REFERENCE.	1-10
A,E	US 5,794,140 A (SAWYER) 11 AUGUST 1998; ABSTRACT.	1-10
A,P	US 5,701,295 A (BALES ET AL) 23 DECEMBER 1997; ABSTRACT.	1-10
A	US 5,633,859 A (JAIN ET AL) 27 MAY 1997; ABSTRACT.	1-10
A	US 5,625,879 A (TUULOS) 29 APRIL 1997, ABSTRACT.	1-10



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*A* document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
*E* earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*Z* document member of the same patent family
*O* document referring to an oral disclosure, use, exhibition or other means	
*P* document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

20 OCTOBER 1998

Date of mailing of the international search report

10 NOV 1998

Name and mailing address of the ISA/US  
Commissioner of Patents and Trademarks  
Box PCT  
Washington, D.C. 20231

Facsimile No. (703) 305-3230

Authorized officer

WAYNE D. BOST

Telephone No. (703) 308-7745

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US98/16151

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,379,448 A (Ames et al) 3 January 1995; abstract.	1-10

ORIGINAL  
NO MARGINALIA

This Page Is Inserted by IFW Operations  
and is not a part of the Official Record

## **BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

## **IMAGES ARE BEST AVAILABLE COPY.**

As rescanning documents *will not* correct images,  
Please do not report the images to the  
Image Problem Mailbox.